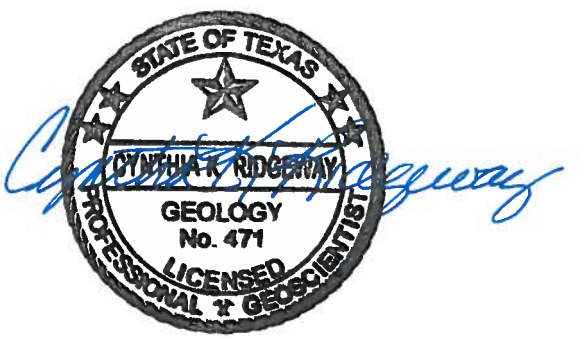
GAM Run 10-059 MAG Version 2: Groundwater Management Area 10 Model Runs to Estimate Springflow under Assumed Future Pumping and Recharge Conditions for the Northern Subdivision of the Edwards (Balcones Fault Zone) Aquifer

by William R. Hutchison, Ph.D., P.E., P.G. and Wade Oliver[1]
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-3132[1]

Edited and finalized by Marius Jigmond to reflect statutory changes effective September 1, 2011

December 7, 2011



Cynthia K. Ridgeway, the Manager of the Groundwater Availability Modeling Section and Interim Director of the Groundwater Resources Division, is responsible for oversight of work performed by employees under her direct supervision. The seal appearing on this document was authorized by Cynthia K. Ridgeway, P.G. 471 on December 7, 2011.

This page is intentionally blank.

GAM RUN 10-059 MAG VERSION 2: GROUNDWATER MANAGEMENT AREA 10 MODEL RUNS TO ESTIMATE SPRINGFLOW UNDER ASSUMED FUTURE PUMPING AND RECHARGE CONDITIONS FOR THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER

by William R. Hutchison, Ph.D., P.E., P.G. and Wade Oliver[1]
Texas Water Development Board
Groundwater Resources Division
Groundwater Availability Modeling Section
(512) 463-3132[1]

Edited and finalized by Marius Jigmond to reflect statutory changes effective September 1, 2011

December 7, 2011

EXECUTIVE SUMMARY:

Two desired future conditions were adopted by the members of Groundwater Management Area 10 for the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer – one for average recharge conditions and one for extreme drought conditions. The modeled available groundwater as a result of the desired future condition under average recharge conditions is approximately 11,557 acre-feet per year. This is shown by county, regional water planning area, and river basin as shown in Table 1. Of this pumping, 11,528 acre-feet per year is within Barton Springs/Edwards Aquifer Conservation District. These estimates were developed with a model run based on the methods used in GAM Run 09-019.

For extreme drought conditions, the modeled available groundwater of 3,765 acre-feet per year was estimated using a water balance approach based on information provided by the district supporting an approximate one-to-one relationship between springflow and pumping under low-flow conditions. This pumping is also summarized in Table 1 by county, regional water planning area, and river basin.

REQUESTOR:

Mr. Rick Illgner of the Edwards Aquifer Authority on behalf of Groundwater Management Area 10

DESCRIPTION OF REQUEST:

In a letter dated August 24, 2010 and received September 2, 2010, Mr. Rick Illgner provided the Texas Water Development Board (TWDB) with the desired future conditions of the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer adopted by the members of Groundwater Management Area (GMA) 10. The desired future conditions, as shown in Resolution No. 2010-02, are as follows:

> Springflow of Barton Springs during average recharge conditions shall be no less than 49.7 cubic feet per second (cfs) averaged over an 84-month (seven-year) period; and
>
> During extreme drought conditions, including those as severe as a recurrence of the 1950's drought of record, springflow of Barton Springs shall be no less than 6.5 cubic feet per second (cfs), averaged on a monthly basis.

In response to receiving the adopted desired future conditions, the Texas Water Development Board has estimated the modeled available groundwater for Groundwater Management Area 10 for the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer for both average recharge and extreme drought conditions.

METHODS:

The locations of Groundwater Management Area 10 and the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer are shown in Figure 1. The Texas Water Development Board previously completed several predictive groundwater model simulations of the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer to assist the members of Groundwater Management Area 10 in developing a desired future condition. These simulations are documented in Groundwater Availability Modeling (GAM) Run 09-019 (Hutchison and Hill, 2011). The specific annual pumping amounts simulated in the previous model runs included 3,847; 4,469; 5,437; 6,796; and 16,311 acre-feet per year. Relative frequencies of various springflows based on these pumping assumptions were then estimated over a wide range of recharge and initial condition assumptions. These model runs are referenced in the desired future condition resolution of Groundwater Management Area 10. However, the specified average pumping amount (16 cubic feet per second), average springflow (49.7 cubic feet per second), and the minimum drought

condition springflow (6.5 cubic feet per second) were not explicitly simulated in GAM Run 09-019 (Hutchison and Hill, 2011). As outlined in the resolution, the average springflow and pumping for average recharge conditions were estimated based on interpolation of the previous simulations. Therefore, part of the effort in this report was to confirm the average springflow and associated average pumping adopted in the desired future condition resolution with an additional set of model simulations similar to those presented in GAM Run 09-019.

As described below, the additional simulations confirmed that pumping of 11,557 acre-feet per year within Groundwater Management Area 10 (approximately 16 cubic feet per second) will result in an average springflow of 49.7 cubic feet per second. Though the series of 342 7-year simulations contained a wide range of recharge conditions, average springflows among the simulations correspond to average recharge conditions.

This pumping of 11,557 acre-feet per year for average recharge conditions was divided by county, regional water planning area, river basin, and groundwater conservation district (Figure 2). Note in Figure 2 that only the Barton Springs/Edwards Aquifer Conservation District and Edwards Aquifer Authority are shown. This is because these are the only two districts within Groundwater Management Area 10 that manage the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer.

The desired future condition statement also provides for a drought-condition desired future condition that was adopted after considering GAM Run 09-019 and the Barton Springs/Edwards Aquifer Conservation District's 2004 report titled "Sustainable Yield Study" (Smith and Hunt, 2004). As stated in the desired future condition resolution, pumping reductions during drought conditions are a management tool of the Barton Springs/Edwards Aquifer Conservation District. Neither the simulations in GAM Run 09-019 nor the additional model simulations completed as part of this report assumed reductions in pumping due to drought conditions. These simulations could not, therefore, be used to directly assess springflows under drought conditions given the management strategy of the district.

However, as summarized in Technical Note 2011-0707 provided by Barton Springs/Edwards Aquifer Conservation District on July 7, 2011 to the Texas Water Development Board, multiple numerical modeling studies support an approximate one-to-one relationship between springflow and pumping under low-flow conditions (Hunt and others, 2011). Given a total water budget estimated by the district of 11.7 cubic feet per second (8,470 acre-feet per year) available for discharge during extreme drought conditions (Hunt and others, 2011) and the minimum drought condition springflow of 6.5 cubic feet per second (4,705 acre-feet per year), the available pumping under extreme

drought conditions was estimated to be approximately 5.2 cubic feet per second (3,765 acre-feet per year). The modeled available groundwater for extreme drought conditions using this water balance approach, which is distinct from the approach used for average recharge conditions, is presented separately in the results section below.

PARAMETERS AND ASSUMPTIONS:

Modeled Approach for Average Recharge Conditions

- The model recalibrated to include the 1950s drought for the Barton Springs segment of the Edwards (Balcones Fault Zone) Aquifer was used for estimating modeled available groundwater during average recharge conditions (Hutchison and Hill, in preparation).

- Similar to GAM Run 09-019 (Hutchison and Hill, 2011), the simulations consisted of 342 7-year simulations extending from 1648 through 1995 based on a tree-ring dataset from Cleaveland (2006). Each 7-year simulation consisted of 84 monthly stress periods.

- Pumping of 11,557 acre-feet per year in Groundwater Management Area 10 was assumed and implemented by multiplying estimated 2002 pumping from the model by a factor of 2.13 in order to achieve the assumed pumping.

Water Balance Approach for Extreme Drought Conditions

- A water balance approach was used to estimate modeled available groundwater during extreme drought conditions based on information provided by Barton Springs/Edwards Aquifer Conservation District. See Hunt and others (2011) for additional details on the methods and assumptions for this approach.

- The total amount of water available for discharge by both springs and pumping during extreme drought conditions (11.7 cubic feet per second or 8,470 acre-feet per year) was estimated using information from the 1950's drought of record as described in Hunt and others (2011).

- The water balance approach described here does not contain information about the spatial distribution of pumping. For the purposes of regional water planning, the estimated total pumping available during extreme drought conditions was divided by county, regional water planning area, river basin, and groundwater conservation district based on the distribution of pumping in the modeled approach above.

Modeled Available Groundwater and Permitting

As defined in Chapter 36 of the Texas Water Code, "modeled available groundwater" is the estimated average amount of water that may be produced annually to achieve a desired future condition. This is distinct from "managed available groundwater," shown in the draft version of this report dated July 21, 2011, which was a permitting value and accounted for the estimated use of the aquifer exempt from permitting. This change was made to reflect changes in statute by the 82nd Texas Legislature, effective September 1, 2011.

Groundwater conservation districts are required to consider modeled available groundwater, along with several other factors, when issuing permits in order to manage groundwater production to achieve the desired future condition(s). The other factors districts must consider include annual precipitation and production patterns, the estimated amount of pumping exempt from permitting, existing permits, and a reasonable estimate of actual groundwater production under existing permits. The estimated amount of pumping exempt from permitting, which the Texas Water Development Board is now required to develop after soliciting input from applicable groundwater conservation districts, will be provided in a separate report.

RESULTS:

Results of the additional model simulations are summarized in Figures 3 and 4. Figure 3 presents the cumulative distribution of springflow for the entire set of simulations (342 7-year simulations), which totals 28,728 months. Note that springflows below 6.5 cubic feet per second occur less than 0.5 percent of the time even though simulated pumping was not reduced during drought conditions. Though the estimated pumping for extreme drought conditions presented below was derived using a separate water balance approach, the modeling results are consistent with the conclusion that the drought condition desired future condition can be met given the management practice of Barton Springs/Edwards Aquifer Conservation District to reduce pumping during drought.

Figure 4 presents the average monthly springflow for each of the 342 7-year simulations plotted against the average precipitation for the corresponding 7-year period. Note that the average springflow for all 342 7-year periods is 49.7 cubic feet per second. Further, note that at any particular precipitation condition, there is considerable variation in the average springflow. This expected variation will be an important consideration when the Barton Springs/Edwards Aquifer Conservation District compiles springflow data and compares them to the desired future condition.

Based on the analysis described here, the modeled available groundwater for average recharge conditions for the northern subdivision of the Edwards (Balcones Fault Zone) Aquifer in Groundwater Management Area 10 as a result of the desired future condition is 11,557 acre-feet per year. This has been divided by county, regional water planning area, and river basin for each decade between 2010 and 2060 for use in the regional water planning process (Table 1).

As described above, for extreme drought conditions the modeled available groundwater is 3,765 acre-feet per year. This represents approximately 32.6 percent of the modeled available groundwater under average conditions. Since the water budget approach used to develop this estimate does not contain information about the spatial distribution of pumping, the results were divided by county, regional water planning area, and river basin based on the distribution of pumping during average conditions. Specifically, the modeled available groundwater under average conditions was multiplied by 32.6 percent to yield the modeled available groundwater during extreme drought conditions in each area (Table 1).

The modeled available groundwater for both average recharge and extreme drought conditions is also summarized by county, regional water planning area, river basin, and groundwater conservation district as shown in tables 2, 3, 4, and 5, respectively. In Table 5, note that Barton Springs/Edwards Aquifer Conservation District is the only district relevant to the desired future conditions. This excludes the Edwards Aquifer Authority because the desired future condition and modeled available groundwater in this area was set by the Texas Legislature during the 80th Legislative Session.

LIMITATIONS:

The groundwater model used in completing this analysis is the best available scientific tool that can be used to meet the stated objective(s). To the extent that this analysis will be used for planning purposes and/or regulatory purposes related to pumping in the past and into the future, it is important to recognize the assumptions and limitations associated with the use of the results. In reviewing the use of models in environmental regulatory decision making, the National Research Council (2007) noted:

> "Models will always be constrained by computational limitations, assumptions, and knowledge gaps. They can best be viewed as tools to help inform decisions rather than as machines to generate truth or make decisions. Scientific advances will never make it possible to build a perfect model that accounts for every aspect of reality or to prove that a given model is correct in all respects for a particular regulatory application. These characteristics make evaluation of a regulatory model

> more complex than solely a comparison of measurement data with model results."

A key aspect of using the groundwater model to evaluate the impacts of future pumping is the need to make assumptions about the location in the aquifer where future pumping will occur. As actual pumping changes in the future, it will be necessary to evaluate the amount of that pumping as well as its location in the context of the assumptions associated with this analysis. Evaluating the amount and location of future pumping is as important as evaluating the changes in groundwater levels, spring flows, and other metrics that describe the impacts of that pumping. This analysis does not assess the possible impacts of pumping such as reduced water quality or land surface subsidence.

In addition, certain assumptions have been made regarding future precipitation, recharge, and streamflow in evaluating the impacts of future pumping. Those assumptions also need to be considered and compared to actual future data.

Given these limitations, users of this information are cautioned that the results should not be considered a definitive, permanent prediction of the changes in groundwater storage, streamflow and spring flow. Because the application of the groundwater availability model was designed to address regional scale questions, the results are most effective on a regional scale. The TWDB makes no warranties or representations relating to the actual conditions of any aquifer at a particular location or at a particular time.

It is important for groundwater conservation districts to monitor future groundwater pumping and overall conditions of the aquifer. Because of the limitations of the groundwater availability model and the assumptions in this analysis, it is important that the groundwater conservation districts work with the TWDB to refine this analysis in the future given the reality of how the aquifer responds to the actual amount and location of pumping now and in the future.

REFERENCES:

Cleaveland, M.K., 2006, Extended chronology of drought in the San Antonio area, revised report: University of Arkansas, 29 p. http://www.gbra.org/Documents/Reports/TreeRingStudy.pdf

Hunt, B.B., Smith, B.A., Holland, W.F., 2011, Technical Note 2011-0707: Information in Support of the Drought DFC and Drought MAG, Barton Springs Segment of the Edwards Aquifer, Barton Springs/Edwards Aquifer Conservation District, 5 p.

Hutchison, W.R. and Hill, M.E., Recalibration of the Edwards (Balcones Fault Zone) – Barton Springs Segment – Groundwater Flow Model, Texas Water Development Board, 115 p.

Hutchison, W.R. and Hill, M.E., 2011, GAM Run 09-019: Groundwater Model Runs to Estimate Monthly Average Discharge from Barton Springs under Alternative Pumping Scenarios and Alternative Initial Conditions, June 1, 2011, 29 p.

National Research Council, 2007, Models in Environmental Regulatory Decision Making. Committee on Models in the Regulatory Decision Process, National Academies Press, Washington D.C., 287 p.

Smith, B.A. and Hunt, B.B., 2004, Evaluation of Sustainable Yield of the Barton Springs Segment of the Edwards Aquifer, Hays and Travis Counties, Central Texas: Barton Springs/Edwards Aquifer Conservation District, 197 p.

TABLE 1: MODELED AVAILABLE GROUNDWATER FOR THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER IN GROUNDWATER MANAGEMENT AREA 10 FOR BOTH AVERAGE RECHARGE AND EXTREME DROUGHT CONDITIONS. RESULTS ARE IN ACRE-FEET PER YEAR AND ARE DIVIDED BY COUNTY, REGIONAL WATER PLANNING AREA, AND RIVER BASIN.

Recharge Condition	*County*	*Region*	*Basin*	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Average	Hays	K	Colorado	7,037	7,037	7,037	7,037	7,037	7,037
Average	Hays	L	Guadalupe	942	942	942	942	942	942
Average	Travis	K	Colorado	3,578	3,578	3,578	3,578	3,578	3,578
Total for Average Recharge Conditions				**11,557**	**11,557**	**11,557**	**11,557**	**11,557**	**11,557**
Drought	Hays	K	Colorado	2,292	2,292	2,292	2,292	2,292	2,292
Drought	Hays	L	Guadalupe	307	307	307	307	307	307
Drought	Travis	K	Colorado	1,166	1,166	1,166	1,166	1,166	1,166
Total for Extreme Drought Recharge Conditions				**3,765**	**3,765**	**3,765**	**3,765**	**3,765**	**3,765**

TABLE 2: MODELED AVAILABLE GROUNDWATER FOR THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER SUMMARIZED BY COUNTY IN GROUNDWATER MANAGEMENT AREA 10 FOR EACH DECADE BETWEEN 2010 AND 2060 FOR BOTH AVERAGE RECHARGE AND EXTREME DROUGHT CONDITIONS. RESULTS ARE IN ACRE-FEET PER YEAR.

Recharge Condition	*County*	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Average	Hays	7,979	7,979	7,979	7,979	7,979	7,979
Average	Travis	3,578	3,578	3,578	3,578	3,578	3,578
Total for Average Recharge Conditions		**11,557**	**11,557**	**11,557**	**11,557**	**11,557**	**11,557**
Drought	Hays	2,599	2,599	2,599	2,599	2,599	2,599
Drought	Travis	1,166	1,166	1,166	1,166	1,166	1,166
Total for Extreme Drought Recharge Conditions		**3,765**	**3,765**	**3,765**	**3,765**	**3,765**	**3,765**

TABLE 3: MODELED AVAILABLE GROUNDWATER FOR THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER SUMMARIZED BY REGIONAL WATER PLANNING AREA IN GROUNDWATER MANAGEMENT AREA 10 FOR EACH DECADE BETWEEN 2010 AND 2060 FOR BOTH AVERAGE RECHARGE AND EXTREME DROUGHT CONDITIONS. RESULTS ARE IN ACRE-FEET PER YEAR.

Recharge Condition	*Region*	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Average	K	10,615	10,615	10,615	10,615	10,615	10,615
Average	L	942	942	942	942	942	942
Total for Average Recharge Conditions		**11,557**	**11,557**	**11,557**	**11,557**	**11,557**	**11,557**
Drought	K	3,458	3,458	3,458	3,458	3,458	3,458
Drought	L	307	307	307	307	307	307
Total for Extreme Drought Recharge Conditions		**3,765**	**3,765**	**3,765**	**3,765**	**3,765**	**3,765**

TABLE 4: MODELED AVAILABLE GROUNDWATER FOR THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER SUMMARIZED BY RIVER BASIN IN GROUNDWATER MANAGEMENT AREA 10 FOR EACH DECADE BETWEEN 2010 AND 2060 FOR BOTH AVERAGE RECHARGE AND EXTREME DROUGHT CONDITIONS. RESULTS ARE IN ACRE-FEET PER YEAR.

Recharge Condition	*Basin*	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Average	Colorado	10,615	10,615	10,615	10,615	10,615	10,615
Average	Guadalupe	942	942	942	942	942	942
Total for Average Recharge Conditions		**11,557**	**11,557**	**11,557**	**11,557**	**11,557**	**11,557**
Drought	Colorado	3,458	3,458	3,458	3,458	3,458	3,458
Drought	Guadalupe	307	307	307	307	307	307
Total for Extreme Drought Recharge Conditions		**3,765**	**3,765**	**3,765**	**3,765**	**3,765**	**3,765**

TABLE 5: MODELED AVAILABLE GROUNDWATER FOR THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER SUMMARIZED BY GROUNDWATER CONSERVATION DISTRICT IN GROUNDWATER MANAGEMENT AREA 10 FOR EACH DECADE BETWEEN 2010 AND 2060 FOR BOTH AVERAGE RECHARGE AND EXTREME DROUGHT CONDITIONS. RESULTS ARE IN ACRE-FEET PER YEAR.

Recharge Condition	*Groundwater Conservation District*	*2010*	*2020*	*2030*	*2040*	*2050*	*2060*
Average	Barton Springs/Edwards Aquifer Conservation District	11,528	11,528	11,528	11,528	11,528	11,528
Average	Edwards Aquifer Authority and Non-District Areas	29	29	29	29	29	29
Total for Average Recharge Conditions		**11,557**	**11,557**	**11,557**	**11,557**	**11,557**	**11,557**
Drought	Barton Springs/Edwards Aquifer Conservation District	3,756	3,756	3,756	3,756	3,756	3,756
Drought	Edwards Aquifer Authority and Non-District Areas	9	9	9	9	9	9
Total for Extreme Drought Recharge Conditions		**3,765**	**3,765**	**3,765**	**3,765**	**3,765**	**3,765**

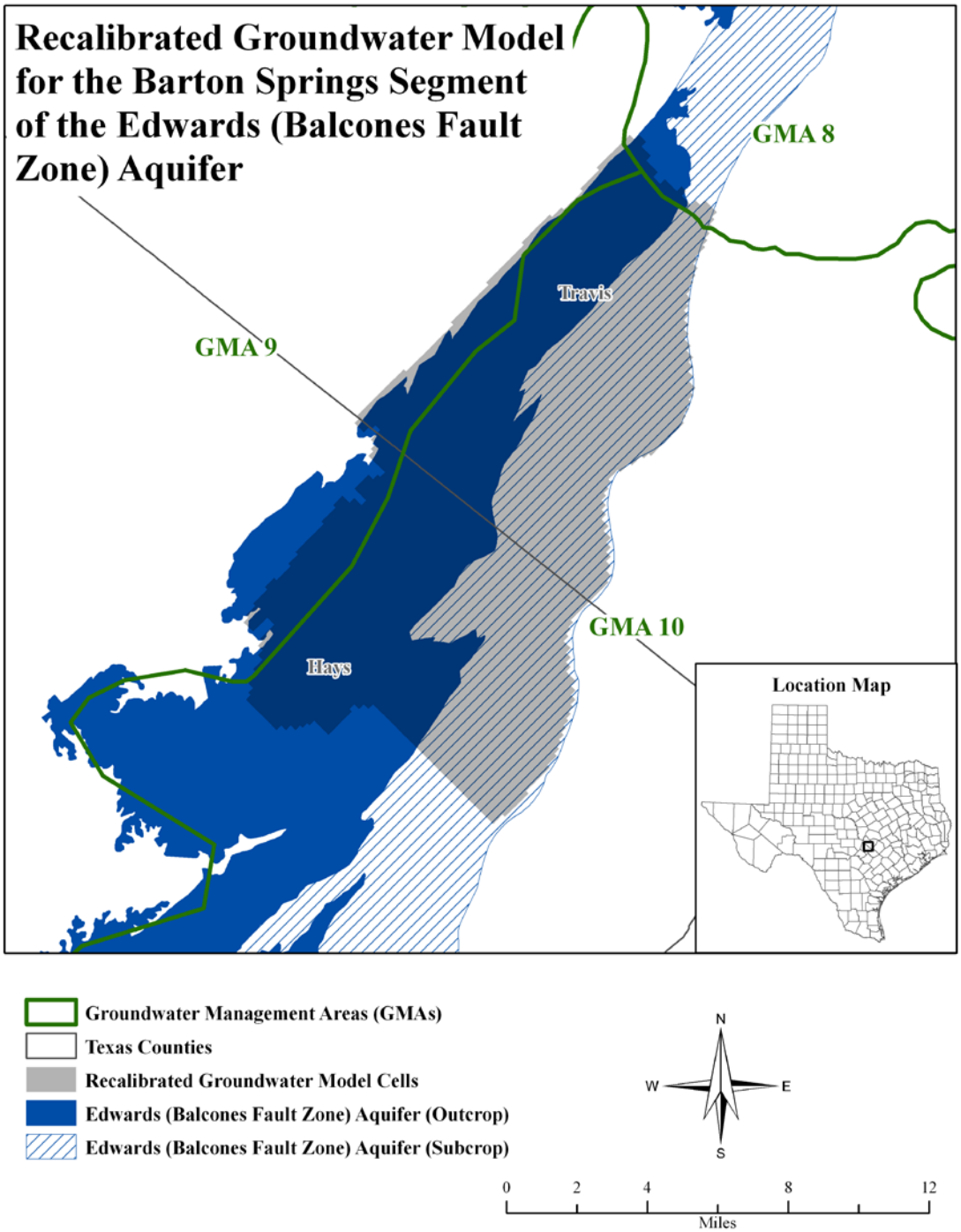


FIGURE 1. MAP SHOWING THE AREAS COVERED BY THE GROUNDWATER MODEL REPRESENTING THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER.

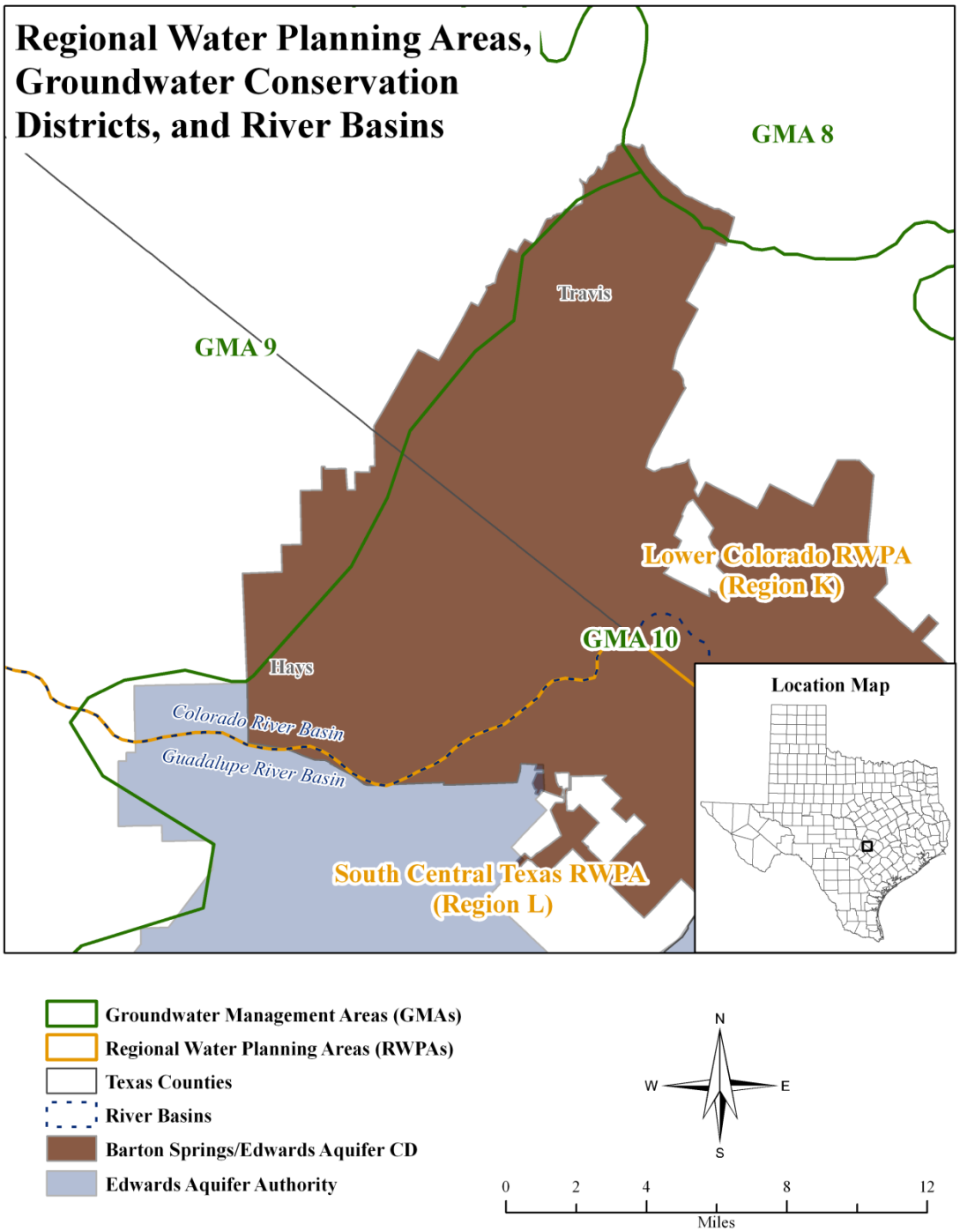


FIGURE 2. MAP SHOWING REGIONAL WATER PLANNING AREAS, GROUNDWATER CONSERVATION DISTRICTS, COUNTIES, AND RIVER BASINS IN GROUNDWATER MANAGEMENT AREA 10 RELEVANT TO THE NORTHERN SUBDIVISION OF THE EDWARDS (BALCONES FAULT ZONE) AQUIFER.

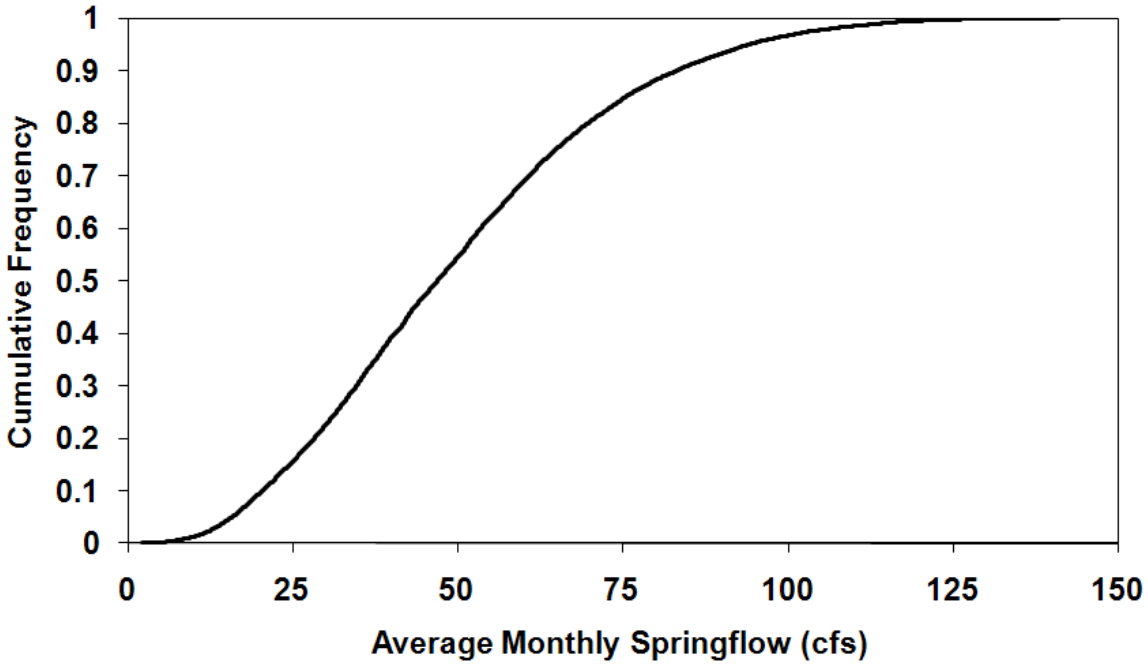


FIGURE 3. CUMULATIVE DISTRIBUTION OF AVERAGE MONTHLY SPRINGFLOW FOR BARTON SPRINGS BASED ON 342 7-YEAR SIMULATIONS WITH PUMPING AT 11,557 ACRE-FEET PER YEAR (16 CUBIC FEET PER SECOND) ASSUMING NO REDUCTIONS DURING DROUGHT.

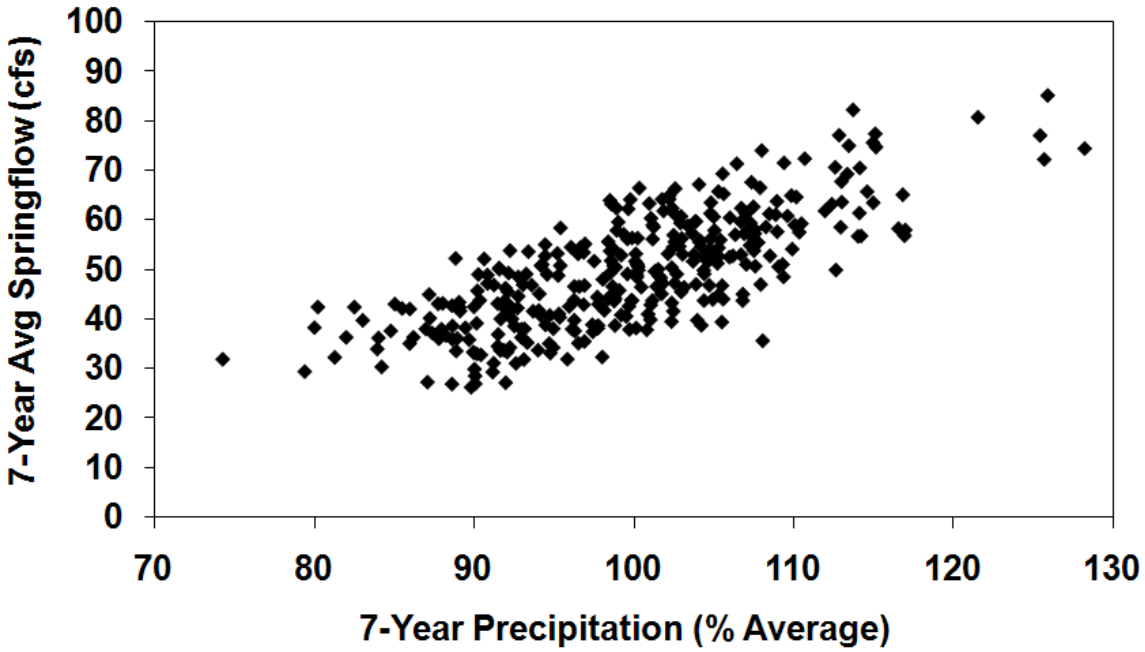


FIGURE 4. 7-YEAR PRECIPITATION VERSUS 7-YEAR AVERAGE SPRINGFLOW BASED ON 342 SIMULATIONS ASSUMING 11,557 ACRE-FEET OF ANNUAL PUMPING (16 CUBIC FEET PER SECOND).